THE CHANGING ROLE OF UGS IN THE NETHERLANDS UNDER THE INFLUENCE OF LIBERALIZATION AND GRONINGEN DEPLETION AND POSSIBLE CONSEQUENCES FOR THE SECURITY OF GAS SUPPLY

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ABSTRACT

The structure of the Dutch gas supply system is undergoing some profound changes. The decline of the Groningen field and the ongoing liberalization process are two important reasons for this. This paper deals with the effects of these two developments on the availability of flexibility in the supply system. In particular, the increasing role of underground storage in flexibility provision is discussed. First the main sources of flexibility are identified, after which the determining factors for their availability on the market are analyzed. Next, using a simulation model of the Dutch gas supply system, three scenarios are constructed with varying assumptions about the future structure of the Dutch market: a “Perfect Market” scenario where availability is enforced by regulation; a “High Barriers” scenario where the government is largely absent and companies have to secure flexibility on their own; and an “Uncertainty Prevails” scenario where the government sends out mixed signals and companies operate under high uncertainty.

The results show that enforcing access to existing flexibility sources improves short term security of supply but weakens long term security. Not enforcing access raises entry barriers and operating costs but improves long term security. Choosing the middle road combines the worst of both worlds, endangering both short and long term security. These scenarios imply that adequate investment in UGS hinges on the reduction of uncertainty about the future market structure as well as the specific regulatory regime in place. Such investments are in turn essential for maintaining security of supply in general. Both policy makers and industry parties need to consider the above in developing their strategies for securing flexibility.
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1. INTRODUCTION

Security of gas supply has always been a major concern for suppliers of gas, consumers of gas and governments alike. Since the 1990’s it has received increasing attention from the research community as well. The International Energy Agency (IEA) was the first to study this subject [1]. Recent additions to this field of research include Stern [2, 3] and Wright [4]. There are several different aspects of security to consider when studying gas supply. This paper deals with one aspect in particular, that of flexibility. Flexibility means the ability of suppliers to adjust the amount of gas they supply to changes in demand. The IEA has conducted the most comprehensive study to date about flexibility [5]. In recent years, an important development in flexibility provision in Western Europe has been the increasing importance of underground storage (UGS). In fact, the use of UGS has become indispensable in maintaining security of supply. In this paper the role of UGS as a source of flexibility is discussed in a case study of the Netherlands.

Traditionally, Dutch gas supply has been dominated by the huge Groningen field in terms of both volume and flexibility. In other words, a large share of the gas supplied came from Groningen (from about 80% in the 70’s to 30% in the 90’s) and the daily and seasonal variation in demand was accommodated by adjusting the production from the Groningen field. However, in recent years two developments have heralded a departure from the status quo that will significantly change the way gas is supplied to Dutch consumers.

First, production from the Groningen field is in decline, which means its swing capacity will start to decrease. In response, the formerly integrated Dutch transport and supply company Gasunie has started using three UGS-facilities to offset the decrease in swing capacity and additional measures will be required in the future.

Second, because of the ongoing liberalization process, there is much uncertainty about the future availability of flexibility to market parties. The outcome of the negotiations over the Groningen field are still uncertain and Gasunie has provided limited access to its UGS-facilities on the basis of the Gas Directive’s derogation principle. These uncertainties have made some companies decide to build their own UGS-facilities, e.g. Akzo/GTS/Nuon’s Zuidwending salt cavern initiative. Whether such initiatives will become a trend or remain incidental is yet to be seen.

The replacement of Groningen flexibility and the outcome of the liberalization process will together determine the future of UGS as a source of flexibility. What that future will look like is highly uncertain at this moment in time. This paper sketches three scenarios for the future of UGS as a source of flexibility as well as the implications of each scenario for security of supply. In Section 2, a quantitative measure for flexibility is developed to enable estimates of its future technical availability. The factors that will determine the actual availability of this flexibility on the market are identified in Section 3. Section 4 introduces a simulation model of the Dutch gas supply system that includes those factors. In Section 5, the three market scenarios are presented along with the model results they generate. The implications of these results for security of supply in general and UGS in particular are discussed in Section 6. Finally, Section 7 provides some concluding remarks.

2. INCORPORATING FLEXIBILITY IN A QUANTITATIVE MODEL

Flexibility in gas supply can be defined as a supplier’s ability to either decrease or, more frequently, increase supply in response to a change in demand. One of the aims of this paper is to quantify the amount of flexibility that is technically available in the Dutch gas supply system. To do this, four basic sources of flexibility must be taken into account. These are swing capacity, linepack, storage facilities and interruptible contracts. They are described in more detail below. It is important to note that system flexibility is related non-linearly to the chosen unit of time. Therefore, the
appropriate quantifier for each flexibility source also depends on the time unit. This issue is discussed separately for each of the four sources.

**Swing capacity:** the existence of spare production capacity in gas reservoirs is often referred to as swing capacity. The amount of swing capacity contracted by a supplier is expressed as a dimensionless swing factor. This factor equals the maximum daily amount of gas the buyer is entitled to, divided by his average daily demand over a longer period, usually a year.

**Linepack:** the pipes of the transmission network can contain an amount of gas in addition to the gas that is actually transported through the network by simply increasing the pressure on part of the network. The excess gas can leave the network when necessary, thereby acting as a source of flexibility. The amount of linepack available is determined by the design of the network and the network operator’s policy. It is assumed to be used hourly and to add up to zero on a daily basis.

**Storage facilities:** a storage facility can be either a depleted gas reservoir, a salt cavern or an LNG storage and regasification plant. Gas is injected into such a facility to be produced again at a convenient time. The main variables that determine the use of a storage facility are injection capacity, storage capacity, production capacity and start-up time. Storage facilities can be roughly divided into volume shifters and peak shavers. Volume shifters have higher storage capacities and production capacities, longer start-up times and a longer injection/production cycle. Peak shavers can start-up almost instantly and have short cycles, but also have smaller production and storage capacities. On a daily basis, production capacity determines flexibility. On a seasonal basis though, the storage capacity divided by the production capacity is also important as it determines for how many days the flexibility is available.

**Interruptible customers:** the right to interrupt supply to a customer is a special form of flexibility. It differs from the above three in that it decreases the demand faced by a supplier instead of increasing its supply. In effect, a supplier that has an interruption agreement with a customer gains the right to shift supply from that customer to another for a number of days per year. An alternative to this scenario could be that a customer receives gas as usual but then resells it on a spot market as soon as the spot price is higher than a customer’s costs of interruption. In this case the customer is still a source of flexibility, but this flexibility enters the system through a spot market rather than directly via the supplier. An interruptible customer’s contribution to flexibility is measured in a way similar to that of a storage facility. On a daily basis, the most important variable is a customer's consumption, which determines the volume available on a given day. This bears resemblance to a storage's production capacity. In an interruptible contract, the number of days a customer can be interrupted is specified for a year. This limits the number of days per year for which this source is available.

These sources have to be made compatible to enable quantification of the total system flexibility in a model. To do so requires all sources to be expressed in the same unit. For the model referred to in this paper (see Section 4), the unit chosen is cubic metres per day (m$^3$/d). A shorter timescale would require a detailed physical model of gas flows through the transmission network. Instead it is assumed that linepack will take care of intraday fluctuations in supply. On the other hand, a longer timescale could mask non-linearities (e.g. a shortage on day one might be compensated by a surplus on day two). This arrangement enables the quantification of flexibility on a peak demand day. In addition, to also address the issue of a peak demand winter, the model includes limits to the number of days per year these sources can be used. Regarding the quantification of the amount of gas, the choice for cubic meters rather than Joules is determined by the convention of expressing production capacities in m$^3$/day and the advantage of being able to disregard quality conversion.

When this model is applied to the Dutch situation it shows some trends over the past forty years. After the introduction of natural gas in Dutch society in the 1960’s, all flexibility in the Dutch supply system was provided by the swing capacity of the Groningen field, along with some linepack to smooth out local intraday disturbances. Over the years however, Groningen swing capacity
declined gradually, prompting the construction of three UGS-facilities and an LNG peak shaver in the 1990’s to compensate for this flexibility loss. In addition, some companies are making use of UGS-facilities in Germany, near the Dutch border. Interruptible contracts used to be virtually absent (with the notable exception of some export contracts), as customers were guaranteed uninterrupted supply and designed their installations accordingly. However, with the uncertainty about future arrangements increasing, this is starting to change. Figure 1 shows a sample load duration curve generated by the model used in this study. Specifically, it shows the contribution of different flexibility sources in terms of capacity (the vertical axis) and volume (the area under the curve).

Another issue with regard to flexibility is whether the structure of the supply system allows utilization of this flexibility in such a way that gas supply is secure. In other words, is the flexibility that is technically available also available on the market? The market conditions necessary for an adequate utilization are discussed in the next section.

3. THE MARKET AVAILABILITY OF FLEXIBILITY

The previous section discussed the amount of flexibility available in the Dutch supply system. This section discusses a relatively new issue: the distribution of flexibility over different market parties. This issue was created by the gradual liberalization of the Dutch gas industry implemented over the last ten years. Before liberalization, Gasunie was a monopolist in the areas of buying from producers, transporting gas across the Netherlands, exporting it to other countries and selling gas to consumers and utilities. As Gasunie owned both the exclusive Groningen supply contract and the transmission system with its linepack, it had unrestricted access to all sources of flexibility. It was also involved in the construction of the first storage facilities and became the sole user of their flexibility.

After liberalization however, the structure of the supply system was changed in several important ways. As one of the aims of liberalization was to introduce competition in segments of the
supply chain that had always been monopolies, the supply branch of Gasunie now has to compete with other suppliers. For other suppliers to be able to compete however, they need access to sources of flexibility. The effect of liberalization on the accessibility of each of the sources is discussed in more detail below.

**Swing capacity:** in principle any field can supply swing, but to do so requires large investments in facilities. In the Netherlands a ‘small fields policy’ is still in place where the government stimulates the development of small fields by offering attractive conditions to producers. An important condition for flexibility purposes is the guaranteed constant high load factor (which means low swing). This means that Groningen is the main swing producer in the Netherlands, along with only a few smaller fields. In theory, swing could also be supplied by foreign fields. However, the response time of such fields is constrained by their distance to the market and the design of their facilities. The time it takes to adjust production and deliver the extra gas produced to the market determines the reach of a swing producer. As a quasi-monopolist in swing, the owner of the Groningen field is a powerful player in the flexibility area. The way it decides to distribute its flexibility will have a serious effect on the total availability of flexibility. Several options are discussed in the scenarios in section 5.

**Linepack:** linepack used to be a tool for the incumbent monopolist Gasunie to balance supply and demand on an hourly basis. Now it belongs to the transport company and is used for correcting intraday imbalances between entry and exit points caused by shippers. In this way it could be argued all shippers have access to linepack flexibility. However, it is unclear how much is available and at what price. No maximum amount of imbalance is stated by the transport company and prices are linked to spot prices for gas. This implies that, at times of scarcity, using linepack offers no advantages over using the spot market.

**Storage facilities:** the availability of storage flexibility is largely dependent on the issue of third party access (TPA). This principle from the EU gas directive states that all infrastructure should be made available to any party wishing to utilize it. However, the gas directive also states that access can be denied if it causes either a lack of capacity or an impediment to the obligatory provision of a public service. To which extent the right to deny access will be used is still unclear and is discussed in the scenarios of section 5. Another problem is the fact that the use of storage facilities is offered in ‘bundles’ that are too large for many users.

**Interruptible customers:** liberalization has not changed the fundamentals of interruptible contracting; it is still a matter to be decided by consumer and supplier. What has changed are the incentives for working with interruptible contracts. From the supplier’s perspective, it is a good way of smoothing out the supply profile and thereby reducing the need for other sources of flexibility which may be hard to find in the new environment. From the consumer’s perspective, two arguments in favor of interruption exist. First, he may feel that security can no longer be counted on and he therefore needs to have a backup system in place. If he has such a system anyway, he might as well profit from it by signing an interruptible contract. Second, if a liquid spot market is in place, the price he can get for gas on the spot market might be higher than the costs he incurs for not using the gas himself.

The key uncertainties facing suppliers concerning access to flexibility are structured through the development of three scenarios which will be elaborated in Section 5. First, the model used to run these scenarios is described in Section 4.

### 4. A SIMULATION MODEL OF THE DUTCH GAS SUPPLY SYSTEM

In an earlier study [6], a model of the Dutch gas supply system was built to investigate developments in flexibility. Its most important features are described briefly. First, all flexibility sources are included except for linepack. This means gas fields and UGS-facilities are modeled physically at a reservoir level, and supply contracts can be modeled as either interruptible or firm.
Second, actors are used to simulate all different market parties: producers, transmission system operators, storage operators, distributors, consumers and finally the supplier as the key actor. These actors are linked through bilateral contracts, spot markets or, if a company operates in different segments, an intra-company link. A sample actor network is shown in Figure 2. Third, decision algorithms are used by actors as a method to determine their sources of supply and flexibility. Fourth, technical parameters for available flexibility are estimated using the data set available to the Dutch geological survey as well as the prognoses based on those data. Finally, the possibility of investments (e.g. in UGS-capacity) is also modeled. the likelihood of investment is exogenously determined by combining a theoretical analysis of the investment criteria used by market parties with historical evidence of investment activity.

In principle, any market structure in any country can be analyzed with this model. The model can be adapted to any situation by varying the data set, the number of actors, the number of links between actors and the type of link between them. In most cases, the data set will be the limiting factor. Theoretically, it would also be possible to increase the scope of the model by including more than one country in the model. However, this would require the introduction of explicit regulatory frameworks that differ from country to country.

In the next section three different market structures (the scenarios) are presented, and the model results generated by each scenario are discussed. The differences between scenarios are created by varying the links between actors.

5. SCENARIOS FOR THE DUTCH GAS MARKET

There are many different ways in which the structure of Dutch gas supply could develop. A scenario approach is used to study the different market structures that could emerge and the consequences this could have for the availability of flexibility sources. The market scenarios are extrapolations from the current situation. In each scenario different trends are given greater prominence. Some trends are derived from earlier experiences with liberalization in the UK and US, others are based on more theoretical considerations. The three scenarios are outlined below and the results are summarized in Table 1.

The perfect market scenario is a realization of the original vision of policy makers when liberalization was first initiated. The most important elements of this scenario are liquid spot and term markets; the provision of Groningen flexibility to all parties through either a spot market or multiple bilateral contracts; TPA applied to all UGS-facilities and strictly enforced; many interruptible

Figure 2: example of an actor network showing actors and their contractual relations
customers due to good resale opportunities. This structure is very similar to the market structures in
the UK and US. As perceived in these markets, such a structure provides good utilization of existing
flexibility sources as it facilitates trade and reduces barriers to entry. However, it does not provide
an investment climate that optimizes security of supply. In this scenario companies prefer to buy
their flexibility in a liquid market to making risky investments in sources themselves. This is caused
by the difficulty of acquiring information in a volatile market with many competitors and an emphasis
on short-term efficiency. This leads to a stagnation in the amount of flexibility as investors’
responses are delayed followed by cyclical under- and overcapacity.

The high barriers scenario explores the possibility of the industry remaining fragmented and
hindering the distribution of flexibility. Key elements are the illiquidity of the spot market, limiting its
use; the lack of TPA to UGS because of exemptions, derogations and large bundles; the Groningen
field in the private hands of a single supplier; interruptible customers depending on their supplier’s
compensation. This outlook bears resemblance to the current structure of the German gas industry.
As this type of market lacks institutions for trading, it leads to high entry barriers and the duplication
of flexibility sources. As Wingas’ entry into the German market shows, this leads to higher costs,
but also a secure structure as every supplier is forced to take care of his flexibility independently
and create a secure supply line for himself.

The uncertainty prevails scenario finally, looks at what happens if developments remain
ambiguous over a longer period of time. This scenario is characterized by a spot market that is
founded but hasn’t quite taken off; a continuing uncertainty about the economic future of the
Groningen field; mixed signals about TPA, government intervention and the regulatory future in
general leaving investors hesitant both about UGS and about installations to enable interruptions in
supply. This industry structure is largely a continuation of the status quo in the Netherlands. It leads
to paralysis among suppliers and other investors as they do not know where the industry is headed.
This in turn leads to delayed investments and to limited availability of existing flexibility sources.
6. THE IMPLICATIONS FOR UGS AND SECURITY OF SUPPLY

A comparison of the three scenarios yields the following observations on the future of UGS. First, the use of existing UGS-facilities is promoted by liberalization, but investment in new facilities can be delayed for too long. In a market with intact barriers the access to facilities is limited, but this gives companies an incentive to invest for themselves. If neither of these paths is explicitly chosen, both access to and investment in UGS-facilities is endangered. The main variable to watch over the coming years is therefore the communication (or lack of it) of long-term policy plans by policy makers.

A few things can also be said about the mix of flexibility sources used in the different scenarios. The mix is for a large part determined by the availability of Groningen flexibility. As its availability is (technically) bound to decline over the coming years, the emerging gap will have to be filled by UGS and interruptible customers. What the relative share of these two will be is determined by the costs of UGS construction and utilization versus the costs of building installations that allow consumers to switch to alternative fuels at times of scarcity. A further study including detailed cost analysis for both UGS-facilities and large consumers would be necessary to determine the relative market shares of the two flexibility sources.

Finally, some things can be said about the overall security of gas supply as a function of these scenarios. First, security is jeopardized if the decline in Groningen flexibility is not compensated for. The premise of liberalization is that market forces will provide market parties with the incentives to invest. Whether this is true or not will be determined by the future structure of the market. Second, the model projections show that only in the ‘uncertainty prevails’ scenario a

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Groningen</th>
<th>UGS</th>
<th>Interruptible Customers</th>
<th>Security of supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perfect Market</td>
<td>National flexibility supplier</td>
<td>Availability high, Investment low</td>
<td>Many, Good resale opportunities</td>
<td>Short term high, Long term low</td>
</tr>
<tr>
<td>High Barriers</td>
<td>Privately owned, No selling obligations</td>
<td>Availability low, Investment fair</td>
<td>Average, Resale limited to own supplier</td>
<td>Short term medium, Long term high</td>
</tr>
<tr>
<td>Uncertainty Prevails</td>
<td>No decision made</td>
<td>Availability low, Investment low</td>
<td>Few, Limited resale opportunities</td>
<td>Short term medium, Long term low</td>
</tr>
</tbody>
</table>

Table 1: Summary of scenario results
structural lack of flexibility will develop. However, in the perfect market scenario security is also endangered in the longer term because of cyclical under- and overinvestment. Third, these results have implications for all parties involved. Policy makers should keep in mind the trade-off between security of gas supply and other policy objectives such as efficiency. Possible efficiency gains should be quantified and weighed against the decrease in security that accompanies it. Industry parties should consider their options for acquiring flexibility and design a strategy that is robust for each of the scenarios described.

7. CONCLUSIONS

A major change lies ahead in the way the Dutch gas industry provides flexibility to its customers due to Groningen depletion and liberalization. It is likely that UGS will play an increasingly important role in this provision. This paper has identified the determining factors for the development of UGS in the Netherlands and analyzed them through a scenario approach. The three scenarios explored show that both the amount of flexibility that is technically available and its effective distribution depend on market structure. In one of the scenarios the security of supply is jeopardized. Policy makers and industry parties should be aware of the possible risks that lie ahead and incorporate it in their strategy. Policy makers should focus the liberalization framework by making a clear choice between either actively ensuring the availability of flexibility to all parties or placing the responsibility with individual parties to create their own flexibility. Industry parties should be prepared to act on both scenarios.

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